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The cow-calf industry in the southern United States accounts for approximately 50 percent of all the mature beef cows in the country and generates $7 billion in total farm income annually (Little, 1985). Cow-calf production is the major beef enterprise in Louisiana where a total of 668,000 mature beef cows produce an annual income of $145 million (Fielder and Nelson, 1982). This report also indicates that most steers were transported to other states after weaning with only 10 percent of all male calves remaining in Louisiana. These facts demonstrate that the present beef industry in Louisiana is almost totally dependent upon the cow-calf sector for generating income.

The majority of beef producers in Louisiana and the south breed cows to calve in the spring to match production requirements of cattle with forage production patterns. The primary forages used in beef cattle production systems in the southeast are the summer perennial grasses, i.e., bermudagrass and bahiagrass. Quality of warm season perennials is generally highest in the spring and early summer (Dienum et al., 1968). Also, rainfall patterns (NOAA, 1983) in Louisiana show higher average monthly totals in the late spring and early summer than late in the summer. Consumption of high quality forage allows cows to produce ample amounts of milk for calves and conditions them for breeding again.

The American Forage and Grassland Council (1974) estimated more than a billion acres of forage land in the United States produce only about 25 percent of their potential. This forage grazing land represents a major resource that has a large potential for expansion. Previous research at this location (Carpenter et al., 1979) found that fall calving of beef cows is possible as an alternative to spring calving. In that study, conception rates were higher than 90 percent for cows calving in the fall. Creep grazing of calves onto high quality ryegrass pastures increased calf weaning weight. Hoveland and Anthony (1979) in Alabama found that using

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cool season annual grasses, such as ryegrass, lengthened the grazing season by as much as 3 months when overseeded into perennial grass sods. The quality of cool season annuals and the performance of animals grazing them have been shown to be higher than warm season perennials, such as bermudagrass and bahiagrass (Utley et al., 1975 and 1976). Wilson (1984) reported that the efficiency of nitrogen fertilizer was greater for warm season perennial grasses, yielding a greater forage yield per unit of nitrogen applied than for cool season grasses. This suggests that high stocking rate systems are more feasible for spring-calving cows because of greater forage production in response to nitrogen fertilizer applications in the summer.

The objectives of this research were to compare fall- and spring-calving beef cows and to compare the effect of two stocking rates on animal productivity. Data were obtained for cow weights, cow reproductive performance, and calf weights.

Experimental Procedure

Four beef cow-calf management systems were evaluated over 5 years comparing one stocking rate with another and one calving season with another. The experiment was conducted on Coastal Plains soil in western Louisiana using multiparous Angus and Hereford x Angus cows. Climatic data were collected during the study (Appendixes A, B, and C).

Management of Cattle

A total of 160 Angus and Hereford x Angus multiparous cows were used each year during a 5-year study beginning in September 1976 to determine the effects of calving season and stocking rate on animal performance. The four treatments were [1] low stocking rate (35 cows per 30 acres), fall-calving (September through November); [2] high stocking rate (45 cows per 30 acres), fall-calving; [3] low stocking rate, spring-calving (January through March); and [4] high stocking rate, spring-calving. All groups were allotted 30 acres on which they were maintained year-round. Initially, cows were blocked according to season of calving and allotted to groups within a calving season at random. Once allotted to treatment groups, cows remained in that group unless removed from the study because of a failure to rebreed, death of a calf or cow, or a physical injury severe enough to adversely affect cow or calf performance. Cows failing to rebreed were replaced at weaning time; other replacements were made as necessary. Replacement cows were randomly selected from a group of 3-year-old heifers calving in the same season as the cows they were replacing. Once placed in a herd, animals remained in that herd until the conclusion of the study or until replaced.

The breeding season was 75 days long, scheduled to produce cows calving from either September 1 until November 15 (fall-calving season) or January 1 until March 15 (spring-calving season). Hereford or Angus bulls were alternated within herds during the breeding season. The same four (two Angus and two Hereford) bulls were used during the 5-year study on both fall- and spring-calving cows. A single bull was placed with each cow herd during the respective breeding seasons. Bulls were rested one week and worked one week during the breeding season. Bulls were rotated between herds during the study so that each bull had the opportunity to mate any cow. Cows were rectally palpated 3 to 4 months after the end of the breeding season to determine pregnancy status. Open cows were sold after calves were weaned.

Calves were permanently identified at birth and their dam numbers recorded. All calves were weighed at birth, and male calves were castrated either surgically or by banding. All calves were vaccinated at birth against scours and at 4 months against clostridial (Blackleg) diseases. At 4 months old, heifer calves were vaccinated against brucellosis (Bang's Disease), and steers were given a growth implant. Calves were weighed and assigned feeder grade scores at an average age of 205 days and at weaning. Calf weights were adjusted for age and sex at 205 days and at weaning. Average age at weaning was 9 months.

Cows were weighed in early December, April, June, and at weaning. Cows and calves were observed at least once each day and more often during calving season. Preventive vaccinations for vibriosis and leptospirosis were given annually, and cows were treated for internal parasites as necessary. A trace mineralized salt mixture containing supplemental calcium, phosphorus, and iodine was available to animals at all times.

Days spent grazing and days on hay and supplement were monitored. Cows were fed a good quality common bermudagrass hay during periods of inadequate forage production, primarily during winter. Hay was fed inside portable hay panels with slanted-bar openings to reduce waste. Supplemental cottonseed meal was fed to cows at a rate of 1 pound per head daily prior to half the cow herd calving and at a rate of 2 pounds per head daily after more than half the herd had calved. Cottonseed meal was hand-fed daily in open troughs.

Each cow-calf treatment group was managed independently of other groups. The objective within each group was to manage cattle and pastures to optimize productivity of cattle through proper forage management.

Pasture Management

Four 30-acre units of similar soil types and previous management were used for this study. The soils were typical Coastal Plain soils (Aquic, Plinthaquic, and Plinthic Paleudults), being primarily Bowie and Angie fine sandy loam soils with 3 to 5 percent slopes. All units consisted of 23 acres (one 3-acre and two 10-acre pastures) of permanent grass and one 7-acre prepared seedbed. Permanent grass pastures were primarily common bermudagrass with some Coastal bermudagrass. These three pastures were overseeded each fall with ryegrass (variety Gulf) and white clover (variety La. S-1) at seeding rates of 25 and 3 pounds per acre, respectively. Ryegrass and clover were planted using a grain drill with single disk openers on 7-inch centers. Pastures were closely grazed or harvested for hay just prior to sodseeding in an attempt to maximize good soil-to-seed contact and reduce grass competition.

The prepared seedbed area was thoroughly disked each fall prior to planting a mixture of rye (variety Elbon), ryegrass, and white clover (variety Regal) at seeding rates of 60, 20, and 5 pounds per acre, respectively. Rye and ryegrass were planted with a grain drill (described above) using two passes over the field. Clover was planted from a clover seeding attachment on the grain drill and allowed to fall freely to the ground rather than being planted in the same drill row with ryegrass. Rye and ryegrass were planted perpendicular to each other to maximize ground cover and reduce competition. The prepared seedbed was firmed with a cultipacker after planting to conserve soil moisture.

Pastures were rotationally grazed by cows. Calves had access to all pasture within a system through creep gates or creep holes in fences. These creep openings were 16 inches wide and 48 inches high. Occasionally cows were allowed to limit graze the prepared seedbeds during periods when forage accumulation exceeded calf consumption. Limit grazing is the practice of allowing cows access to pastures for 2 hours per day, 2 to 5 days per week, depending on forage availability.

Excess forage was harvested as hay and credited to the unit from which it was cut. Herbicides were used as necessary to control undesirable plants, particularly pigweed. Insecticides were used as necessary, primarily to control fall armyworms.

Fertilization Practices

Nitrogen fertilizer was applied at rates of 282 and 291 pounds per acre on permanent pastures and prepared seedbeds, respectively. Some of the nitrogen was applied in September as a complete fertilizer (9 percent nitrogen, 23 percent phosphorous, and 30 percent potassium). Most of the nitrogen was applied as ammonium nitrate (34 percent nitrogen) in four equal applications at 3-month intervals beginning in October.

Soil samples were taken in each pasture within a unit and all pastures received a complete fertilizer, according to the recommendations of Tisdale and Nelson (1975). Samples were analyzed for phosphorus, potassium, magnesium, and soil pH. Average annual fertilizer inputs for bermudagrass pastures in all units were 46 and 110 pounds per acre of P_2O_5 (phosphate) and K_2O (potassium), respectively. Dolomitic lime was applied at a rate of 1,000 pounds per acre and used because of its magnesium content, which has a role in the prevention of grass tetany disease. Lime was applied to maintain a soil pH of at least 6.2 for good clover production. Prepared seedbeds required more fertilizer inputs and generally received annual applications of 69, 140, and 1,000 pounds per acre of P_2O_5, K_2O, and lime, respectively.

All phosphate fertilizer and lime were applied in the fall; potassium was applied in both the fall and spring. Fertilizers were bulk spread by a commercial applicator.

Statistical Analysis

The experimental unit in this study was the herd managment unit; each year of the study served as a replicate. Calf weights at 205 days of age and at weaning were adjusted for age and sex of the calf and age of the dam. The General Linear Models procedure (SAS, 1979) was used to analyze data collected in this study. Calf 205-day weights and grades and weaning weights and grades were tested for significance by least-squares analysis of variance (Steel and Torrie, 1980). A model including year, herd unit, and year x herd unit was used to analyze the 768 calf weights and grades. The model used to analyze cow ($n=775$) weights and ages included year, herd, and year x herd. All cow and calf data were reported as least-squares means. There was an interaction ($P<.05$) between stocking rate and calving season for all calf weights and grades and most of the cow weights by months. Therefore, means were compared using preplanned contrasts to test for specific differences between herd management systems. The standard errors associated with means in tables were averages of the standard errors for each herd unit because little variance was observed between individual means. Sample analysis of variance models used for cow and calf data can be found in appendixes D and E.

Hay production, hay consumption, days on supplemental feed, and protein supplement consumed were analyzed by analysis of variance and tested for treatment mean differences by least significant differences (Snedecor and Cochran, 1967).

Economic Analysis

Cost and return analyses were based on average inputs for individual cow-calf management systems. Performance characteristics were based on least-squares means generated from the statistical analysis. Where statistical differences did not exist between treatment means, the average values for all units were used in the economic analysis. Prices for inputs and outputs were based on averages for Louisiana during this period of study. Prices for weanling calves were based on average values for the month of weaning (Fielder and Osagie, 1985).

Results and Discussion

Cows were rotationally grazed between pastures within an individual system (Figure 1). Calves were allowed to creep graze into any pasture within a unit. Previous research at this location (Carpenter et al., 1979) found that allowing calves to creep graze increased calf weaning weights and also increased profits in those cow-calf systems. The pasture system used in the present study was shown by Carpenter et al. (1979) to optimize calf weaning weight, net profitability, and hay production. In the earlier study, excess hay was produced in the system equivalent to the one used in this study, indicating that stocking rate was too low (30 mature animals on 30 acres) to fully evaluate all systems. In the present study, stocking rates were increased in an attempt to reduce excess hay production. Obviously, it is more economical and energy-efficient to graze forages than to harvest the excess as hay, store, and feed it to cattle at a later date. Some hay is required in any year-round system because of the seasonality of forage production.

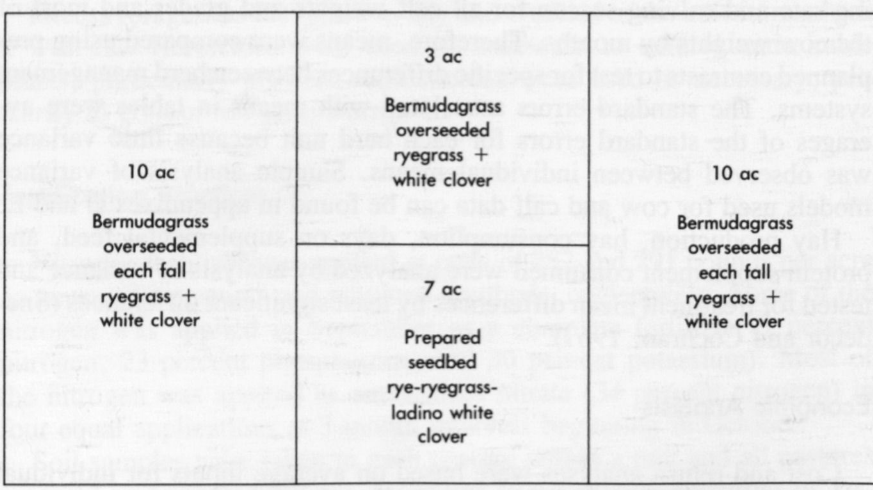

Figure 1. Representative pasture management scheme for all cow-calf units.

The amount of hay harvested (Table 1) was greater in spring-calving herds (15.3 tons) than in fall-calving herds (14 tons). Units 1 and 3 with lower stocking rates (1.17 cow-calf pairs per acre) produced more excess forage for hay than did units 2 and 4 with higher stocking rates (1.50 cow-calf pairs per acre). All units were hay deficient when demands for hay by cows during the winter was much greater than hay production. Hay deficits were greater in fall-calving herds (units 1 and 2) and systems with higher stocking rates (units 2 and 4).

The number of days cows received supplemental feeds were greater for fall-calving herds and those with high stocking rates (1.50 cow-calf pairs per unit). Feeding hay and supplemental feed was begun at about the same time for all cow groups. Prior to initiation of the study, it was felt that spring-calving units would probably require earlier supplemental feeding than fall-calving units. Spring-calving units had cows and calves on units until the weaning date of November 15. These older calves exerted heavier grazing pressure on available forage than the younger fall-born calves. However, hay feeding was generally initiated for all systems in late November in response to frosts which killed the available bermudagrass. Fall-calving cows might have gone a few days longer before being put on hay and supplemental feed, but the decision was made to put them on earlier to avoid any nutritional stress. The fall-calving cows were under greater nutritional stress than spring-calving cows because they had to produce milk for young suckling calves and then breed again. Fall-calving cows require a greater amount of higher quality feed in early winter compared with the spring-calving cows that had already weaned their calves and were in the latter stages of pregnancy (NRC, 1984). Dunn et al. (1969) reported that increasing the digestible energy intake of beef cows after calving resulted in increased conception rates when cows were in adequate condition prior to calving. Stricker et al. (1979) found that varying the nutrition levels of beef cows resulted in significant changes in conception rates. Conception rates in that study ranged from 28 to 80 percent, with higher conception rates associated with higher energy intakes. These studies indicated that the condition of cows prior to calving may be equally or more important than the nutritional level after calving in determining whether or not a cow will rebreed.

The amount of hay fed per cow during the wintering phase was greater for fall-calving (1.26 tons per cow) than for spring-calving cows (1.05 tons per cow). Part of this increased hay consumption resulted from the wintering period being an average of 5 days longer for fall-calving cows but, more importantly, resulted from the greater nutritional stress and nutrient demands on fall-calving cows. The hay feeding period was also longer for fall-calving cows because of the greater grazing pressure exerted by their calves, compared with spring-born calves, in March and

Table 1.—The effects of calving season and stocking rate on hay production and supplemental feeds in cow-calf management systems

Unit	Calving season	Stocking rate[1]	Hay harvested	Hay fed		Days on supplemental feed	Protein supplement[2] fed	
				Per unit	Per cow		Per unit	Per cow
		Cows/acre	Tons	Tons	Tons		Tons	Pounds
1	Fall	1.17	16.1	41.7	1.19	88	3.1	177
2	Fall	1.50	11.9	59.7	1.33	107	4.1	182
Average			14.0	50.7	1.26	98	3.6	180
3	Spring	1.17	16.8	33.6	.96	79	1.5	86
4	Spring	1.50	13.8	51.2	1.14	106	1.9	84
Average			15.3	42.4	1.05	93	1.7	85
S.E.			2.6	7.4		5.5	.6	

[1]All units contained 30 acres. Units 1 and 3 had 35 cows and units 2 and 4 had 45 cows.
[2]Supplement was cottonseed meal containing 41 percent crude protein.

April. During the late winter to early spring period, fall-born calves (5 to 6 months old) were actively grazing and consuming a substantial amount of forage. Spring-born calves were still very young (1 to 2 months old) and generally got most of their nutrient requirements from milk; they did not consume much forage.

Protein supplement (cottonseed meal) was fed any time cows were fed hay. Fall-calving cows received 2 pounds and spring-calving cows received 1 pound of cottonseed meal per head daily until more than half of the cows had calved. After that point, cows were fed 2 pounds of supplement per head daily. This feeding program resulted in spring-calving cows consuming much less protein supplement than fall-calving cows (Table 1).

Weights of fall- and spring-calving cows were not significantly different in December (Comparison 1, Table 2), but fall-calving cows were heavier ($P<.05$) in April, June, and at weaning than spring-calving cows. Fall-calving cows lost an average of 29 pounds and spring-calving cows lost 49 pounds from December until April. This period included the calving season for spring-calving cows, which could explain the greater magnitude of weight loss. The April weight represented the lowest average weight for both fall- and spring-calving cows. The maximum average weight changes for fall-calving cows was 79 pounds (1,027 pounds at weaning in July to 948 pounds in April) compared with 58 pounds (986 pounds in June to 928 pounds in April) for spring-calving cows. The 1,027-pound weight at weaning probably closely approximates the heaviest weight for fall-calving cows. However, cow weight at weaning may not have been the heaviest weight for spring-calving cows. The weights taken at weaning time were in July and November for fall- and spring-calving cows, respectively. Spring-calving cows would have been expected to continue gaining weight after the June weight, but then to begin losing weight in October and November when forage availability became more limited because of slower forage growth and more total pounds of animals consuming the forages as calves continued to gain weight. Calves were always given priority to the highest quality available forage. Also, the 7-acre creep grazing area (23 percent of the total area) was under cultivation and providing no grazing from mid-September until mid-November, which reduced the area available for grazing.

Cow weights were different at all times (Comparison 2) when comparing fall-calving cows on either low (1.16 cow-calf pairs per acre) or high (1.50 cow-calf pairs per acre) stocking rates. Differences in average weight were least in December (991 vs. 966 pounds for low and high stocking rate, respectively), and tended to be larger at other time periods. Fall-calving cows on the low stocking rate lost 11 pounds per head while high stocking rate cows lost an average of 42 pounds from December until April. This is a critical period, particularly for fall-calving cows since the breeding season began in December. The greater weight losses for high stocking rate cows (Unit 2) may have reduced conception rates. Part of the reason for the greater weight losses of the high stocking rate unit was the lower hay consumption per cow (Table 1). Cows on high stocking rate systems were offered less hay as part of their management system compared with low stocking rate systems. Fall-calving cows on the low stocking rate had an average hay consumpion of 27.1 pounds per day during the winter feeding compared with 24.9 pounds per day of hay for high stocking rate cows. These quantities include waste. This is a difference of 2.2 pounds of hay per day, or almost a 9 percent greater daily hay intake for low compared with high stocking rate cows. The weight differential between fall-calving low (Unit 1) and high (Unit 2) stocking rate cows was maintained through the June and weaning weights. However, cows on the lower stocking rates (Unit 1) lost more weight (−78 pounds) than did high stocking rate cows (−28 pounds) from weaning until the December weight.

Spring-calving cow weights followed the same trends as did fall-calving cows; weights of low and high stocking rate cows were different ($P<.05$) at all periods. However, average weight of spring-calving cows on the high stocking rate was the same for all periods except April, when weight was 59 pounds below other times. Spring-calving, low stocking rate cows tended to vary more in weight from period to period than spring-calving cows on high stocking rates; heaviest weight was recorded in June. Weight differences ($P<.05$) between low and high stocking rates for spring-calving cows were least (38 pounds) in December, but were similar at about 60 pounds at all other dates. Spring-calving cows gained weight from April to June, a period coinciding with breeding season, which likely aided cow milk production and rebreeding.

The graphic presentation of cow weight changes (Figure 2) shows that fall-calving cows were equal to, or heavier than, spring-calving cows at all periods, and that cows were heavier on low than on high stocking rate units. Fall-calving cows lost weight during the breeding season (December 1 through February 15) while spring-calving cows gained weight during their breeding season (April 1 through June 15). However, fall-calving cows were heavier at the weigh date closest to the end of the breeding season (948 pounds in April) than were spring-calving cows (928 pounds in April) at the weigh date closest to the start of their breeding season.

Conception rates of cows (Table 3) were not effected ($P>.05$) by calving season or stocking rate (Comparisons 1, 2, and 3). Fall-calving cows had slightly higher conception rates than did spring-calving cows (93.2 vs. 92.7 percent, respectively) but this difference represented only two more cows conceiving out of a possible 400 cows and was not significant. Fall- and spring-calving cows on high stocking rates had

Table 2.—Weights of cows at various times of the year and average cow age as affected by calving season and stocking rate for cow-calf management systems

	Planned comparisons											
	1				2				3			
					Fall calving				Spring calving			
Month	Fall calving	vs	Spring calving	SE[1]	Low stocking rate	vs	High stocking rate	SE	Low stocking rate	vs	High stocking rate	SE
December, lb	977		977	7.0	991[2]		966[3]	7.0	999[2]		961[3]	7.1
April, lb	948[2]		928[3]	6.7	980[2]		924[3]	6.7	960[2]		902[3]	6.7
June, lb	1006[2]		986[3]	7.4	1042[2]		979[3]	7.3	1020[2]		961[3]	7.5
Weaning[3], lb.	1027[2]		983[3]	6.7	1069[2]		994[3]	6.6	1011[2]		961[3]	6.8

[1]Standard error of the means.

[2]Means in a row within a planned comparison with different superscript letters differ ($P<.05$).

[3]Weaning dates were mid-July and mid-November for fall- and spring-calving cows, respectively.

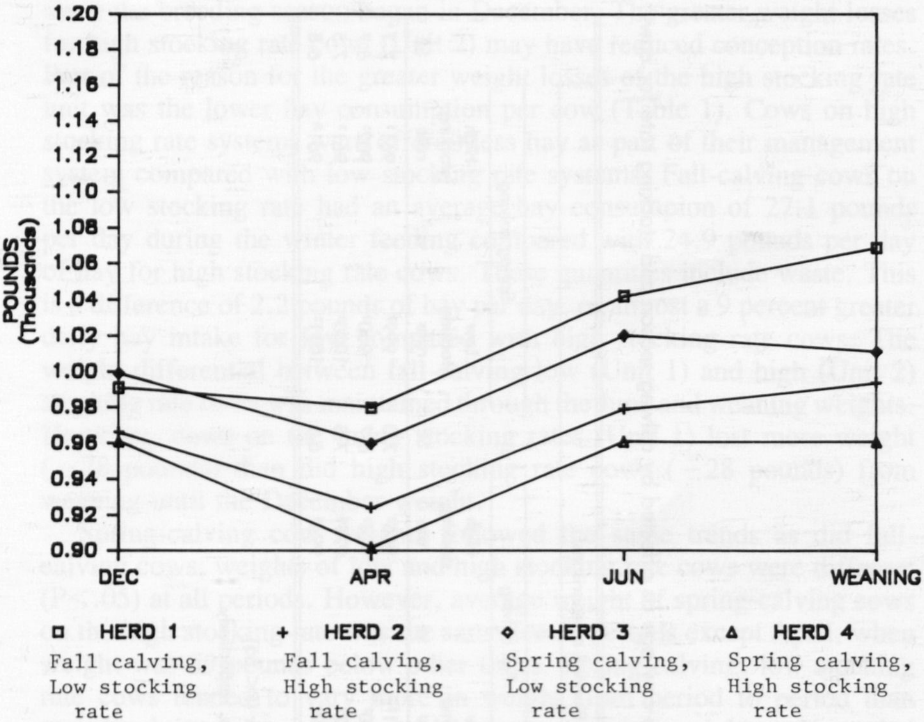

Figure 2. Average cow weight by herd management treatment for different months.

slightly lower conception rates than did cows on low stocking rate systems (91.7 vs. 94.0 percent, respectively). While these differences in conception rate were not significant (P>.05), they would have an economic impact if these trends were real. The difference of 3.4 percent between fall-calving cows for low and high stocking rate (94.9 vs. 91.5 percent, respectively) in this study would represent an additional 1.5 cows per year or 7.5 cows over the 5 years of this study that would fail to rebreed.

Spitzer (1984) reported that following calving, priorities for nutrients in a cow are: maintenance of life, milk production, and, lastly, reproduction. Therefore, reproduction is the first function of a cow that suffers under conditions of poor nutrition. In this study, cows in high stocking rate units had lower body weights than did cows in low stocking rate systems. Table 1 shows that hay consumption by fall-calving high stocking rate cows was almost 9 percent less than consumption by fall-calving cows in low stocking rate systems. This difference in hay consumption and body weight of cows could explain the slightly lower conception rates.

Fall-calving cows in units of low and high stocking rates lost 11 and 42 pounds, respectively, from December until April, the period that included the breeding season. Bellows and Short (1978) reported that higher feed intakes prior to calving increased conception rates and shortened the period between calving and rebreeding.

Spring-calving cows in units of low and high stocking rates gained 60 and 59 pounds, respectively, during the period from April to June, which was during the breeding season. Conception rate was only slightly lower (Table 3) for high stocking rate cows. Whitman (1975) reported that thinner cows had lower conception rates than cows in better condition. Wiltbank et al. (1962) reported that large weight losses during the last few months before calving resulted in cows with low body condition and fewer cows exhibiting estrus early in the subsequent breeding season.

Conception rates were very high for all four herd units, averaging almost 93 percent. Even though some weight losses were seen, cows were apparently maintained in good body condition, which, no doubt, aided reproductive performance. Mature cows were used in this study. This probably aided conception rates since they are not as adversely affected by changing nutritional patterns and loss in weight as heifers or young cows would have been (Fowler, 1969).

Calving intervals were not affected ($P>.05$) by management system. Cows in high stocking rate units (units 2 and 4) had calving intervals similar to low stocking rate units (364.5 vs. 364.6 days). Differences in the calving intervals may have been expected, based on some other data collected in this study, including weight changes and conception rates. In the previous study (Carpenter et al., 1979), differences were observed due to forage management system. In the present study, cows apparently stayed in adequate body condition and received adequate nutrition.

Calf death losses were higher ($P<.05$) for spring-calving than for fall-calving units (5.6 vs. 1.2 percent, comparison 1). Although not reported here, more spring-calving cows, which had been palpated as being pregnant, failed to calve than did fall-calving cows. Most of the death losses in spring-born calves occurred shortly after birth and generally tended to result from climatic conditions. January is the coldest and one of the wettest months at this location (NOAA, 1983). Calves born on very cold, wet days tended to have lower survival rates. Also, diseases were more commonplace with spring-born calves, particularly scours. Fall-born calves were born during a warm, dry time of the year and did not appear to suffer a great deal from climatic factors. However, more insect problems were encountered with young fall-born calves, primarily hornflies.

Each year, several spring-calving cows, which had earlier been palpated as being pregnant, failed to calve. Several late-term aborted fetuses were found during the course of this study. Examinations generally indicated

Table 3.—Conception rates, death loss, age, and calving intervals for cows as affected by calving season and stocking rate in cow-calf management systems

	Planned comparisons									
	1			2			3			
				Fall calving			Spring calving			
Item	Fall calving	vs	Spring calving	Low stocking rate	vs	High stocking rate	Low stocking rate	vs	High stocking rate	SE
Conception rate[1]	93.2		92.7	94.9		91.5	93.1		92.3	
Calving interval,[2] days	364.7		364.5	364.2		365.1	364.9		364.2	2.5
Calf death losses,[5] %	1.2[3]		5.6[4]	.6		1.8	6.3		4.9	
Dam age,[6] years	7.4[3]		6.7[4]	7.2		7.5	6.8		6.6	.2

[1]Percentage of cows palpated as being pregnant 3 to 4 months after the end of the respective breeding seasons.
[2]The days between actual dates of calving for cows.
[3, 4]Means in the same row within a comparison with different superscripts differ ($P<.05$).
[5]The percentage of calves dying through weaning.
[6]Age of cows at the start of calving season each year.

that a physical factor, rather than a disease, caused the abortions. It was speculated that the close contact of the spring-calving cows, while standing around hay sources during the winter, contributed to these physical injuries. Cows were often noticed butting other cows in the side and lower abdominal area in attempts to make room to get to the hay. This physical contact may have caused some of the abortions.

Fall-calving cows were older ($P<.05$) than spring-calving cows at the beginning of their respective calving seasons. This apparently resulted from fall-calving cows remaining in their respective units longer than spring-calving cows. Cows calving in the spring had slightly ($P>.05$) lower conception rates, and had higher calf death losses. Also, more spring-calving cows were replaced from failure to calve during the proper season even though they had been palpated earlier as being pregnant. Cows were usually replaced with 3-year-old cows, which resulted in a reduction in the average cow age within a herd.

Calf birth weights (Table 4) were not different ($P>.05$) because of season of calving (comparison 1) or stocking rate for spring-born calves (comparison 3). However, fall-born calves in low stocking rate units were heavier ($P<.05$) at birth than were calves born in high stocking rate units (comparison 2, 61.8 vs. 59.4 pounds, respectively). Calf birth weights, when expressed as a percentage of the average cow weights at weaning, approximately six weeks before the start of the next calving season, were 5.8, 6.0, 6.1, and 6.4 percent (Figure 3) for fall-calving low and high stocking rates, and spring-calving low and high-stocking rates, respectively. Cows on high stocking rate systems had higher birth weights, when expressed as a percentage of cow weight, than did cows on lower stocking rate systems. This would be expected since the mature physiological size of cows in any herd would be similar because of random allotment of cows to treatments.

Spring-calving cows tended to have heavier calves, expressed as a percentage of cow weight, than did fall-calving cows. Also, the average birth weight was slightly higher for spring-born than for fall-born calves (61.4 vs. 60.5 pounds, respectively). Fall-calving cows weighed an average of 977 pounds compared with spring-calving cows, which weighed only 928 on the dates (December and April, respectively) closest to the end of the calving season. Both groups of cows had lost approximately 50 pounds from the weight closest to beginning and immediately after calving season, but fall-calving cows were heavier initially. Researchers have shown that the primary effects of weight loss in cows prior to calving is that they have a lower subsequent conception rate and a longer interval between parturition and first estrus (Wiltbank et al., 1962 and Dunn et al., 1969).

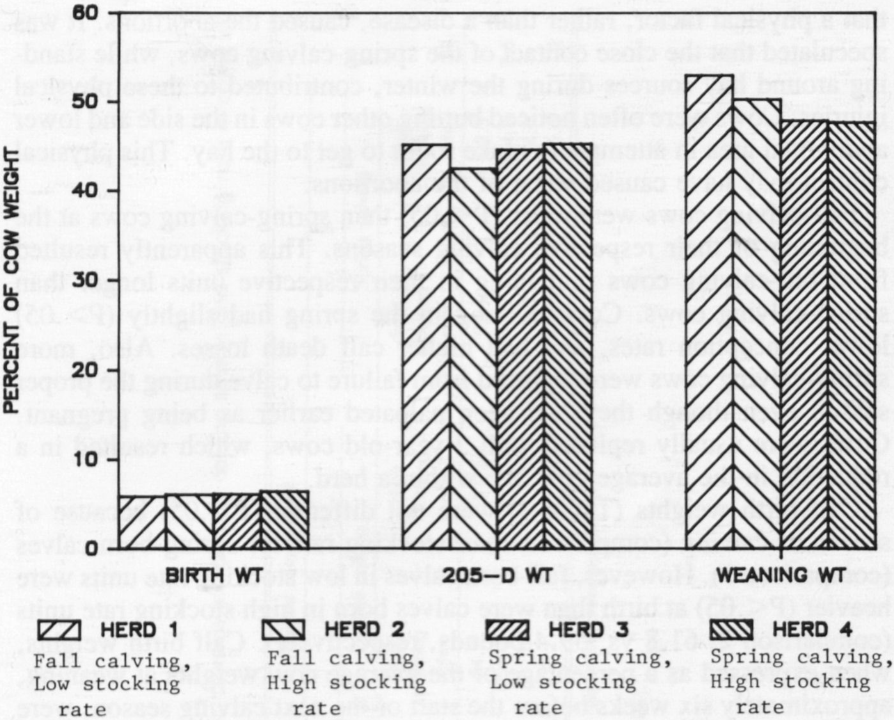

Figure 3. Calf weights at birth, 205 days of age, and at weaning expressed as a percentage of average cow weight.

Weight of calves at 205 days of age were similar between fall- (440 pounds) and spring-born calves (444 pounds). These weights were taken in May and September, respectively. Texas researchers (Talcott and Maddox, 1964) reported that heaviest weaning weights occurred when calves were born in the months of December through April. Both fall- and spring-born calves from the lower stocking rate units were heavier at 205 days of age (comparisons 2 and 3, Table 4) than calves from higher stocking rates (471 and 455 vs. 416 and 435 pounds, respectively). Research work in Texas (Roth, 1984) found that forage quality of Coastal bermudagrass increased under high stocking rates, but forage availability was decreased when sampling pastures down to ground level. However, several researchers (Hodgson, 1982; Guy, 1981; and Ellis et al., 1984) found that the nutritive content of the forages consumed were higher under low stocking rates compared with high stocking rates. Fontenot and Blazer (1965) reported that an increased intake of higher quality forage was due to the greater selectivity afforded cattle in low stocking rate systems. While the quality of the entire forage mass may be low, the part selected is high in quality, and animals are able to consume more in total quantity.

Table 4.—Calf production characteristics as affected by calving season and stocking rate for cow-calf management systems

	Planned comparisons											
	1				2				3			
					Fall-born calves				Spring-born calves			
Item	Fall-born calves	vs	Spring-born calves	SE[1]	Low stocking rate	vs	High stocking rate	SE	Low stocking rate	vs	High stocking rate	SE
Birth weight, lb	60.5		61.4	.6	61.8[2]		59.4[3]	.6	61.6		61.4	.6
205-day weight, lb	440		444	4.3	471[2]		416[3]	4.3	455[2]		435	4.4
205-day grade[4]	12.1		12.1	.1	12.5[2]		11.8[3]	.1	12.0		12.1	.1
Weaning weight, lb	529[2]		470[3]	4.4	567[2]		500[3]	4.4	484[1]		458[3]	4.5
Weaning grade[4]	12.1		12.1	.1	12.4[2]		11.8[2]	.1	12.0		12.1	.1
Weight change from 205 days to weaning[5], lb	89[2]		24[3]		91[2]		84[3]		29[2]		23[3]	

[1]Standard error of the means.

[2,3]Means in the same row within a planned comparison with different superscripts differ($P<.05$).

[4]A visual 17-point feeder calf grade where 11 = high good and 12 = low choice.

[5]Period from early May to mid-July and early Septemer to mid-November for fall- and spring-born calves, respectively.

The higher stocking rate units in this study reduced the amount of available forage for grazing and resulted in below maximum animal gains. Hay production and cow weights were lower in high stocking rate units, indicating that forage availability was lower and did affect performance. While calves were always given preference over cows for available forage, apparently this was not enough to overcome the results of high stocking rate on forage availability.

Fall- and spring-born calf weaning weights were 13.4 and 5.7 percent higher for calves from low compared with high stocking rate systems (comparisons 2 and 3). Cool season grasses (ryegrass) are inherently higher in quality than are warm season grasses (bermudagrass), but forage production with the same amount of nitrogen fertilizer is lower for the cool season grasses (Wilson, 1984). In the present study, the quality of forages available was high, but the availability was apparently low for the fall-born calves from birth until early May. Spring-born calves had more forage available to them from birth until 205-day weights were taken compared with fall-born calves, but quality of the forage was relatively lower.

Feeder grade scores for calves were not different ($P>.05$) between fall- and spring-born calves (comparison 1, Table 4) or between spring-born calves in low or high stocking rate units (comparison 3). However, fall-born calves in low stocking rate units had higher ($P<.05$) feeder grade scores than calves in high stocking rate units (12.5 vs. 11.8, comparison 2). Differences in scores were probably attributable to the low stocking rate calves weighing 55 pounds (13.4 percent) more than fall-born calves from high stocking rate units.

Weaning weights of fall-born calves were heavier ($P<.05$) than spring-born calves (529 vs. 470 pounds, respectively, Table 4). Again, calves from low stocking rate units were heavier ($P<.05$) than high stocking rate units (comparisons 2 and 3). Weight gains for fall- and spring-born calves from the 205-day weight until weaning was 89 and 24 pounds, respectively, which caused weights to be different at weaning but not at 205 days. The time period between the 205-day weight and weaning was from May 1 until July 15 and September 1 though November 15 for fall- and spring-born calves, respectively.

During the spring and early summer, there is usually adequate forage production since this is a period of ample rainfall (NOAA, 1983), and forage quality is relatively high. The primary forages grazed from May to July is ryegrass, white clover and bermudagrass for fall-born calves. Only bermudagrass was available for spring-born calves during the interval between 205-day weights and weaning, from September to mid-November. Researchers have shown that grazing beef steers produce higher daily gains on ryegrass than bermudagrass (Utley et al., 1976; Bagley et al., 1984). Several researchers have also shown that animals grazing grass-clover mixtures have higher daily gains than animals grazing grass pastures (Blaser et al., 1956; Burn et al., 1973; and Van Keuren and Heinemann, 1958). The quality of bermudagrass has also been demonstrated to be lower, in terms of digestibility, late in the summer than in May (Rouquette, 1973, and Villanueva, 1974).

While weaning weights were different for fall- and spring-born calves, calf feeder grade scores were not (Comparison 1, Table 4). This may have been caused by the relatively low feeder grade scores of fall-born, high stocking rate calves (11.8) compared with feeder grade scores of fall-born, low stocking rate calves (12.4). No differences in feeder grade scores were seen between spring-born calves because of stocking rate, since weaning weights differed by only 26 pounds (5.7 percent).

Calf weights, when expressed as a percentage of cow weight, showed that birth weights tended to be higher for high compared with low stocking rate units (Figure 3). Calf weights at 205 days of age relative to cow weights were very similar for the four units. The range was from 42.5 percent (fall-calving, high stocking rate) to 45.3 percent (spring-calving, high stocking rate). Calf weaning weights expressed as a percentage of cow weights showed more variation than did 205-day weights and averaged from 53 percent (fall-calving, low stocking rate) to 47.7 percent (spring-calving, high stocking rate). Fall-born calves tended to have heavier weaning weights expressed as a percentage of cow weights compared with spring-born calves.

Economic analysis of the four cow-calf management units showed that under the current economic conditions of high input costs and low calf prices, a bleak outlook exists (Table 5). Total cash returns per cow were greater for fall-calving and low stocking rate units. However, cash returns per acre were greater for high stocking rate systems compared with low stocking rate systems. Individual calf weaning weights were higher in low stocking rate systems, but pounds of weaned calf produced per acre were greater for high stocking rate systems. Total variable or out-of-pocket expenses were greater for fall-calving than for spring-calving units. Most of the increased costs were associated with wintering fall-calving cows. These cows required more supplemental feeds because they were suckling young calves while trying to rebreed (NRC, 1984). Spring-calving cows had much lower nutrient requirements during the first one-third of the winter feeding periods, since their calving season did not begin until January. Low stocking rate systems had costs that were higher per cow, but lower per acre than did high stocking rate systems.

Net returns were negative per cow (−\$10) and per acre (−\$13) for spring-calving systems. Fall-calving systems were profitable, but returns were low, both per acre and per cow. A primary factor in the profitability of fall-calving systems is the higher price of fall-born calves at weaning

Table 5.—Calf production and economic returns for cow-calf mangement systems as affected by calving season and stocking rate

	Planned comparisons											
	1			2			3			4		
							Fall calving			Spring calving		
Item	Fall calving	vs	Spring calving	Low stocking rate	vs	High stocking rate	Low stocking rate	vs	High stocking rate	Low stocking rate	vs	High stocking rate
Pounds of calf produced												
per cow	529		470	526		479	467		400	484		458
per acre	705		548	614		718	661		750	565		687
Total cash returns[1], $												
per cow	288		244	280		255	309		272	251		238
per acre	384		325	326		382	360		408	293		357
Total variable costs[2], $												
per cow	283		253	285		255	299		270	270		241
per acre	377		337	332		383	349		405	315		362
Total net returns[3], $												
per cow	5		−10	−5		0	9		2	−19		−3
per acre	7		−13	−6		0	10		3	−22		−4

[1]The sale of cull cows was not included in returns.
[2]Included pasture costs of seed, fertilizer, pesticides, labor, machinery, supplemental feeds and veterinary expenses.
[3]Returns are rounded off to the nearest whole dollar.

compared with spring-born calves. Normalized pricing patterns in Louisiana (Fielder and Osagie, 1985) during 1974-84 showed that calves sold in July (fall-born, summer weaned) received an average of 7.3 percent more ($.05 per pound) than did calves sold in November (spring-born, fall-weaned). This combination of higher weaning weights plus a greater price received per pound resulted in the positive economic returns for fall-born calves.

Fall-calving units with low stocking rates tended to have higher returns than did high stocking rate units (comparison 3, Table 5). In contrast, spring-calving units with low stocking rates showed a greater negative return per acre (−$22) than did high stocking rate units (−$4 per acre, comparison 4). Weaning weight differences were large between fall-calving units, but not as large between spring-calving units with different stocking rates. The factors of forage quality and forage yield and their effects on calf productivity are difficult to ascertain in a complete production system such as those evaluated in this study.

Conclusions

Fall-calving cow-calf management units were very productive in this study. Fall-calving resulted in heavier weaning weights and more dollars returned above costs than did spring-calving units. However, fall-calving systems had higher expenses, primarily incurred with winter feeding, and a somewhat greater demand for labor because of more supplemental feeding during the winter. A large advantage of fall calving systems was that calves are born during a relatively warm, dry time with few deaths caused by climatic conditions. In contrast, spring-calving systems did have a higher ($P<.05$) calf death loss, some being directly attributable to prevailing climatic conditions during January through mid-March.

High stocking rates lowered ($P<.05$) average cow weights at all measurement dates compared with low stocking rates for both fall- and spring-calving cows. Reproductive performance was not statistically different between stocking rate groups, but tended to be lower for cows on high stocking rates. Calf weights at 205 days of age and at weaning were lower ($P<.05$) for calves in the high stocking rate systems. Weaning weights of calves from the two different stocking rates differed because of calving season; calves from low stocking rate systems were 13.4 percent and 5.7 percent heavier for fall-born and spring-born calves, respectively. These results point out that available forage for fall-born calves (October through July) are generally higher in quality, but lower in total dry matter yield compared with spring-born calves (February through November), which generally have a lower quality but more available forage.

Low calf prices and higher input costs have contributed to the current low profitability of the cow-calf industry. A major cost in all units was nitrogen fertilizer which was an average of $77 per acre, or almost one-fourth of all costs. Using current prices, the best method of increasing profitability is to increase weaning weights and/or decrease input costs. This increased calf production or decreased cost would have to be accomplished without reducing cow reproduction in order to maintain the same percentage of calves weaned. An apparent method of cutting costs without adversely affecting the system is the use of grass-legume pastures utilizing only limited amounts of nitrogen fertilizer. Studies of this nature have been initiated at this location and will be reported on as they are completed.

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Appendix

Appendix A.—Average temperatures by month at the Rosepine Research Station, 1976-1981

Month	1976	1977	1978	1979	1980	1981
	°F					
January	46.5	39.4	39.5	41.3	51.1	45.0
February	57.1	51.0	41.6	47.7	48.3	50.2
March	60.0	59.3	54.9	58.4	56.4	57.2
April	66.4	65.8	66.6	65.9	62.9	70.5
May	69.4	74.2	73.9	70.9	73.7	71.1
June	76.1	80.6	79.6	78.5	81.1	80.7
July	79.6	83.1	83.1	81.1	84.8	82.6
August	79.6	82.2	82.0	81.2	83.7	82.4
September	75.9	79.5	77.8	75.1	83.0	75.2
October	59.7	66.7	66.9	68.8	63.5	67.3
November	50.5	59.5	62.9	53.8	55.1	60.2
December	47.0	49.6	49.4	49.2	50.3	48.7
Average	64.0	65.9	64.9	64.3	66.2	65.9

Appendix B.—Precipitation by month at the Rosepine Research Station, 1976-1981

Item	1976	1977	1978	1979	1980	1981
January	1.68	5.57	7.83	11.23	5.37	1.94
February	1.82	2.07	3.23	5.94	3.78	3.59
March	7.91	6.81	2.67	6.85	9.40	4.24
April	1.77	5.43	.43	5.80	7.96	1.62
May	4.17	2.34	2.77	6.79	4.90	3.83
June	5.71	1.83	5.42	2.60	1.90	8.01
July	6.62	3.61	4.07	9.63	2.96	6.61
August	3.19	3.58	4.93	1.68	.94	1.48
September	2.06	3.70	2.14	8.75	1.81	3.60
October	2.95	3.95	.45	3.61	2.86	3.53
November	3.71	8.18	5.15	5.53	3.34	2.47
December	6.45	4.58	4.23	5.63	1.53	3.87
Total	48.04	51.65	43.32	74.04	46.75	44.79

Appendix C.—Temperature extremes and freeze data for the Rosepine Research Station, 1976-1981

Item	1976	1977	1978	1979	1980	1981
Temperature extremes						
High	97°	99°	101°	99°	105°	99°
Date	8-2	7-24	8-14	8-6	8-23	8-19
Freeze data						
Last spring date of 32° or below						
Date	3-17	3-8	3-11	3-25	3-4	3-20
Temperature	30°	32°	30°	32°	27°	31°
First fall date of 32° or below						
Date	10-21	11-10	12-14	11-14	10-31	11-21
Temperature	30°	32°	32°	29°	30°	27°
Days between 32° or below readings	218	247	268	234	241	246

Appendix D.—Analysis of variance for cow weights taken in June

Source	Degrees of freedom	Sums of squares
Total	767	6,397,977.2727
Model	19	1,135,237.3605
Year	4	322,894.3085
Herd	3	641,062.6027
Year x herd	12	171,280.4493
Error	748	5,262,739.9122

Appendix E.—Analysis of variance for weaning weights of calves

Source	Degrees of freedom	Sums of squares
Total	771	4,049,472.0869
Model	19	1,634,703.4966
Year	4	246,115.3338
Herd	3	1,182,070.5816
Year x herd	12	206,517.5813
Error	572	2,414,768.5903